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Local Labor Market Effects of Industrial Demand Shocks - Aircraft Manufacturing in the 1990s

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Introduction

An extensive literature has investigated the adjustments of labor markets to geographically concentrated demand shocks, with the primary agent of adjustment being the migration of populations between regions (e.g., Topel, 1986; Blanchard and Katz, 1992; Bound and Holzer, 2000; Gallin, 2004). Most of this literature has considered the case where demand fluctuations affect large and/or disparate regions, such as separate states or metropolitan areas. This focus has the attractive feature that commuting between regions and economic spillovers between regions can be plausibly ignored.

Many of the lessons from this literature may be applied to the case of labor demand fluctuations occurring at more detailed levels of geography, for example between different parts of a metropolitan area or between neighboring counties within a state. In particular, the expected permanence of a shock has important ramifications for the migration decisions of workers (Gallin, 2004), and the direction of the shock may dictate whether residential relocations result primarily in net population changes or compositional shifts (Glaeser and Gyourko, 2005). But neither the extents of these adjustments nor the related changes in market outcomes are well understood.

In this paper, we address this issue by considering the impacts of aircraft manufacturing's early 1990s decline in several, highly concentrated areas on the wages, employment, and population counts of different demographic groups, as well as the related effects on the distribution of housing prices. This aircraft employment episode allows us to observe the reaction of local markets under a particularly intriguing set of circumstances: when the demand shock was unexpected but long-lived; when the shock was a negative one, and when the workers directly affected were of a relatively high skill level.

To measure these effects, we match data from the 1990 and 2000 Censuses of Population, exploiting confidential geographic identifiers. The matching process allows us to delineate small "residence areas" that are consistently defined over the decade; we use the resulting dataset to compare the changes in outcomes of different residence areas and relate them to job shifts caused by the decline of local aircraft manufacturing employment. Due to the timing of the aircraft manufacturing episode, we are able to observe the labor market outcomes characterizing the populations of these small areas both before the local labor demand shock and 7-9 years after it, so that the resulting estimates can be considered to be relatively long-term responses to the episode.

Our analysis generates many striking results, which we can preview here. First, we find that local labor demand shocks like the one we study here have very significant impacts on the distribution of wage rates across space, even in the relatively long run. These impacts are especially large for the demographic groups hit the hardest by the shock, but are significant among all groups we study. Second, we find that both population movements and housing price changes are very large in reaction to local shocks, indicating a major role for the location of employment within metropolitan areas in affecting the long run distribution of residences. Finally, we find evidence of a high degree of re-sorting in the residential locations of workers: in particular, minority populations seem to grow in areas undergoing a negative shock, possibly in pursuit of the concomitant lower housing prices.

Model Sketch: Outlining the Moving Pieces

To help fix our thoughts for the empirical work to follow, it is useful to write down a model that incorporates the variables we will be focusing on. We sketch a model here for this purpose, leaving more detailed treatments of the behaviors involved for further research.

We begin by defining a study area: a broad area at least 50 miles in diameter in which employers and employees (residents) are spread out over space in some unspecified pattern. Within each study area, residents are divided into smaller residence areas, which we index by the subscript i. Employers in the study area are also spatially divided, but we characterize their spatial distribution by a different (broader) set of geographies: we index employment areas by the subscript j. The study area can be thought of as a metropolitan area in which labor can commute across the entire space but prefers to some extent to commute shorter distances. Although residence areas within the study area may be affected by common shocks and study-area-wide trends, we abstract from these effects to focus on the spatial dynamics occurring within the study area.

Employment levels and wage rates are determined through supply and demand conditions at the employers' locations (j), although we will observe the wage rates of residents as they are distributed across residence areas (i). At employment area j, labor supply reflects the number of workers who choose to commute to the area given the wage offered. Let c_{ij} be the fraction of residence area i workers who commute to employment area j; we describe the determination of c_{ij} as a function of $w_{j,}$ the relative wage[1] at employment area j and a set of fixed factors φ_{ij} that govern the relationship between the areas, including the distances between the areas, roadways that link them, and past patterns that have been established by historical commuting patterns:

$$c_{ij} = \varphi_{ij} * w_j^{\gamma}$$

Given a resident population in residence area i, this equation determines the labor supplied from residence area i to employment area j, which we delineate in terms of jobs J_{ij}^S:

$$J_{ij}^S = c_{ij} * pop_i = \varphi_{ij} * w_j^{\gamma} * pop_i$$

[1] We define relative wages here as the ratio of the employment area wage to the weighted (by employment) geometric mean of all employment area wage rates in the study area.

The total labor supply to employment area j is just the sum of the labor supplied from each residence area in the study region:

$$J_j^S = \Sigma_i J_{ij}^S = w_j^\gamma * \Sigma_i \varphi_{ij} * pop_i$$

We note that, since labor supply from each residence area is characterized by a constant wage elasticity, γ, the total labor supply to employment area j is as well:

$$\partial J_j^S / \partial w_j = \gamma.$$

Labor Demand at employment area j is also subject to a constant elasticity: jobs demanded are determined by the employment area relative wage rate and a set of other factors ξ_{ij} that capture area-specific relative advantages of operating in employment area j, including the value of physical capital that might remain from previous investments.

$$J_j^D = \xi_{ij} * w_j^{-\eta}$$

$$\partial J_j^D / \partial w_j = -\eta.$$

We can use these equations to describe the employment area wage in equilibrium as a function of the area-specific factors φ_{ij} and ξ_{ij} and the distribution of the worker population across residence areas. In log form, this is:

$$(\eta + \gamma) * \ln w_j = \ln(\xi_{ij}) - \ln(\Sigma_i \varphi_{ij} * pop_i) \qquad (1)$$

Within a residential area i, we can measure the average log relative wage rate received by a resident; this measure, $\ln w_i$, is simply a weighted average of the employment area relative log wages within the study area:

$$\ln w_i = \Sigma_i [c_{ij} * \ln w_j] = \Sigma_i [(\varphi_{ij} * w_j^\gamma) * \ln w_j]$$

We think of w_i as a characteristic of the residence area: living in i means that a worker will receive, on average, a wage of w_i, given a set of (equilibrium) employer area wages w_j and commuting fractions c_{ij}. In addition, residential equilibrium is affected by residential amenities

a_i characteristic of each residential area; these may include the quality of local public services, proximity to parks, etc. The amenities a_i and the wage rate w_i determine the demand for housing in i, which we express as a relationship between populations (indicated here as pop_i^D to emphasize its role as a driver of housing demanded) and housing prices h_i:

$$pop_i^D = a_i * w_i^\theta * h_i^{-\psi}$$

We have used θ here to represent the responsiveness of population movements to relative wage changes and -ψ as the price elasticity of housing demand. Finally, to close the model, we specify a simple equation expressing housing supply, relating the price of housing to the population living in the residential area:

$$pop_i^S = \kappa_i * h_i^\tau,$$

with κ_i a fixed effect of housing attributes in the area. The parameter τ in this equation captures the price elasticity of housing supplied, with this quantity of housing measured by the population inhabiting it. As other authors (e.g., Glaeser and Gyourko, 2005) have emphasized, this elasticity is likely to be asymmetric: downward shocks are likely to have greater price effects, as housing supply is especially inelastic in that direction. We ignore such considerations here, but since our empirical work focuses on downward shocks, we emphasize a downward elasticity story in our interpretations.

In our empirical work, we are interested in the effect of a negative shock to local labor demand (occurring in employment area j) on the outcomes of residents in the residential areas i. In the context of our model, such a shock is caused by a decline in ξ_{ij}: a decline in the value of the capital stock (aircraft manufacturing plants) in j. In the short run, there is no adjustment in the residential distribution of the population: pop_i remains constant in every area. Therefore, according to equation (1), there must be a decline in $\ln w_j$ equal to $1/(\eta + \gamma)*\Delta\ln(\xi_{ij})$. This is simply a movement along the short run labor supply curve after a shift in the demand curve in employment area j.

The short run impact of this shock on the average wage rate in residential area i reflects the extent to which residents in i disproportionately work in j:

$$\Delta \ln w_i \approx \Sigma_j \, [(c_{ij} - c_j) * \Delta \ln w_j] \qquad (2)$$

$$= (1/ (\eta + \gamma)) \, \Sigma_j \, [(c_{ij} - c_j) * \Delta \ln(\xi_{ij})]$$

where c_j is the fraction of the study area's population employed in j[2]. We see here that the effects of a labor demand shock in a particular employment area on the distribution of wage rates as measure is predicated on two related features of the study area: how different residential areas are in the workplaces of their residents ($c_{ij} - c_j$); and how easy it is for workers to adjust their commuting patterns between employment areas (γ).

In the long run, the wage effect shown in equation (2) may be dissipated by population relocations, as workers move out of residential areas having suffered relative declines in w_i, in turn diminishing the effects on wages themselves. But this allows impacts to accrue to housing prices in the different residential areas. These housing price impacts will be larger the greater is the responsiveness of population to residential area wages (θ) and the smaller the magnitudes of the price elasticities of housing supply and demand (ψ and κ).

The Aircraft Manufacturing Industry: its Concentration and Early-1990s Decline

In 1989, the aircraft manufacturing industry was a major U.S. employer, with an employment of 698,000 workers. This employment was concentrated in a small number of enclaves. Each enclave was anchored by one of the five, final-product producers in the industry

[2] There is also an effect on w_i that comes through changes in the commuting fractions themselves. This effect is second order, and depends critically on the functional form we have chosen here, so we ignore it here for the time

(Boeing in Everett, WA and Wichita, KS; McDonnell Douglas in Long Beach, CA and St. Louis, MO; Northrop in Palmdale, CA; Grumman in Bethpage, NY; and Lockheed Martin in Forth Worth, TX) or one of the large parts suppliers to those manufacturers (Pratt and Whitney in CT; General Electric in OH). Surrounding these anchor employers, many smaller employers manufactured parts or provided contracting services.

These concentrations of employment by place of work resulted in significant concentrations in aircraft employment among the residents of nearby communities. In this paper, we consider several "study areas" – larger areas surrounding these communities. Study areas stretch for 50 miles or more in all directions from the sites where aircraft employment is concentrated. Within these study areas, some residence areas had 10 percent or more of their working residents employed in manufacturing in 1989, while (many) others had none.

Workers in the aircraft manufacturing industry are relatively highly skilled compared to other manufacturing employees. Kronemer and Henneberger (1993) report that labor-saving technology is not relied upon, with adjustments and retooling nearly continuous, customized products prevalent, and precision requirements high. The industry therefore has a high percentage of its production workers involved in craft and technical jobs and a high percentage of its nonproduction workers also having technical expertise. Because of these characteristics, aircraft manufacturers are reluctant to reduce their workforces in response to small or temporary reductions in demand.

Early in the 1990's, however, the U.S. aircraft manufacturing industry underwent several dramatic changes that caused large and seemingly permanent disruptions to demand conditions, and many of the enclaves suffered severe declines in employment. First, in the early 1990s the industry experienced a severe bust that was felt across the nation and, indeed, globally. In the

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being. But it seems to favor residential areas that already have high wage rates. . .

military segment of the industry, the end of the Cold War caused demand for aircraft to fall precipitously. At the same time, a recession and a glut in the commercial airplane market caused demand to bottom out in that segment as well; an industry that had enjoyed a rosy outlook and a multi-year backlog of orders as late as 1989 instead began laying off workers en masse in 1991 and 1992. This decline continued well into the 1990s before beginning to recover somewhat. Figure 1 shows the annual employment reported by the Current Employment Statistics program for aircraft and parts manufacturing from 1987 to 2002. Nationwide employment in this industry declined by 37 percent, from 712,300 to 450,500 employees, between 1990 and 1995. Employment bounced back somewhat in the late 1990s, but the majority of the decline persisted.[3]

A second major change occurring in the industry during this time was a significant reconfiguration of its market structure. During the 1980s, the European consortium Airbus Industrie had gained significant market share in the commercial segment, although healthy demand for new aircrafts kept U.S. employment growing. While demand declined in the early 1990s, Airbus continued to gain market share. As the size of the market diminished, employment was not reduced evenly among different suppliers. Due to high production requirements for efficiencies of scale to be realized, the industry downsized through attrition and consolidation of major suppliers. McDonnell Douglas lost almost all of its commercial business in the early 1990s. When the market started to recover in the middle of the decade, Boeing enjoyed the resulting employment growth while McDonnell Douglas never recovered. In 1997,

[3] Figure 1 shows the pattern of aircraft manufacturing employment through 2002, the last year for which annualized employment is available based on the SIC taxonomy. If the NAICS taxonomy is used, the same pattern is seen, but the series only goes back to 1990. The NAICS taxonomy allows consideration of the trend between 2002 and 2006: during this period aircraft employment declined slightly further but recovered to its 2002 level by 2006.

Boeing swallowed up a failing McDonnell Douglas. In the military segment, the story was similar, as Northrop and Grumman merged in 1995 and were then bought by Lockheed in 1997.

The third significant change in the industry was a transformation in the technology of production. The major contraction of demand and the growth of Airbus imposed increasing competitive pressure on an industry that had long been characterized by high concentration and standing agreements between suppliers and purchasers. As a result, manufacturers began to aggressively seek efficiency improvements through lean production techniques in smaller, new plants and foreign outsourcing. Workers at older, established equipment suppliers such as Pratt and Whitney in CT and General Electric in OH thus suffered substantial employment cuts.

Together, these 3 developments – the decline in aircraft demand, the restructuring of the industry, and the adoption of lean production technologies – caused localized shocks to labor demand. This episode surely caused immediate losses in wages and employment for those workers who were directly affected. Our goal in this paper is to measure its long run consequences for the distribution of market outcomes across space within the study areas we define.

Data

The data in this study come principally from confidential microdata files of the U.S. Censuses of Population in 1990 and 2000, to which we were afforded special access. These Census data provide wage and employment data for approximately one sixth of all U.S. residents, as well as demographic indicators such as race, gender, educational attainment, and age. Our approach to measuring changes in labor market outcomes is to construct indexes of wages, employment, and population that hold the demographic composition fixed over the decade. The unit of measurement for each value of the indexes is a small geographic area, which we create to be consistently defined over the decade.

The Census of Population data contain, in each year, detailed information about the location of each person's residence. This residential location information is coded into entities called "Census blocks," which may be as small as a single city block or, in non-metropolitan areas, much larger areas. Using Census mappings from 1990 block delineations into 2000 block delineations, we aggregated these blocks as necessary into somewhat larger "block clusters" – the smallest geographic delineations that can be made to consistently map data from the 1990 Census into data from the 2000 Census. But block clusters are often much too small to accommodate the calculation of a labor market outcome index; we thus aggregated them into "residence areas."

To create residence area definitions, we ran an aggregation algorithm that grouped block clusters together such that each residence area contained a minimum number of residents in 2000. The algorithm is based on the internal latitude and longitude coordinates for each Census block and follows logic ensuring that residence areas are substantially compact: it accumulates residence areas by adding nearby block clusters together, with incomplete residence areas combining with complete residence areas when they are closer to each other than to ungrouped block clusters. As a base case, we began with a minimum residence area population of 10,000 residents in year 2000. We also explored how the choice of residence area size affects the results by repeating our analyses with residence areas defined to be bigger (minimum of 15,000 residents) and smaller (minimum of 5,000 residents). The trade-off in setting these definitions is between the geographic specificity allowed by smaller areas and the accuracy in our measures afforded by larger areas.

To measure changes in wages, employment, and population within each residence area while controlling for demographic composition changes, we created fixed demographic composition indexes of labor market outcomes. Within each residence area, we divided the Census data into 96 demographic cells on the basis of gender (2), race (2), education (6), and potential experience (4), which we defined as age-years of education-6. Within each residence area-cell, we measured the change over the decade in each of three labor market outcomes: average log wages, log of weeks worked, and log population. We then calculated the earnings share for each of these 96 cells among 12 states containing or near to large aircraft manufacturing presences in 1990 and 2000: CA, CT, IL, IN, KY, MA, MO, NY, OH, OK, RI, and TX. The fixed composition outcome indices combine these elements. They are calculated for broad demographic group or sector *I* in residence area *r* as:

$$O_{ISr}^{fixed} = \sum_{i \in I} (\mu_i \cdot \Delta O_{iSr}), \qquad (3)$$

where ΔO_{iSr} is the change over the decade in a labor market outcome measure for demographic group *i* in residence area *r* within study area *S*, and μ_i is a fixed weight determined by the earnings share over the entire geographic sample of demographic group *i* in the broad category *I*.

We limited our sample of residence areas in the 12 states to only those located in the general vicinity of a large aircraft manufacturing presence that was not owned by Boeing at the outset of the decade. To do so, we identified 8 non-Boeing "study areas," defined by encircling all residence areas having a 1990 aircraft employment fraction of at least 5% with a 50-mile radius, including all residence areas within the radius, and combining the study areas surrounding aircraft employment concentrations within 50 miles of each other. These study areas generally include one or more major manufacturing plants as well as a large surrounding area that may span several states. For example, the study area centering on East Hartford, CT also includes large parts of CT, MA, NY, and RI. This study area is quite large and dense: it comprises 413 residence areas. On the other hand, some study areas are much smaller in terms of the populations they contain; e.g., the study area centering on Rockford, IL comprises only 39 residence areas.

Table 1A gives some summary statistics for the labor market outcome indexes we calculated for each residence area. These statistics are calculated over all 1,951 residence areas in our (8-study-area) sample. The first three rows of the table show the means and standard deviations of the labor market outcome indexes among all residents. For a fixed demographic composition of workers, wages grew by 29.8% over the decade in the average residence area. This fixed population composition also experienced a slight (0.1%) increase in the number of weeks worked per resident, and a population increase of 12.8% in the average residence area. The standard deviations show that there was substantial variation across residence areas in all three of these indexes. Looking down Table 1A, one finds the means and standard deviations of similar indexes calculated over various broad demographic subsamples. These indicate that wage growth was higher among more educated workers and younger workers than among their counterparts, and that population growth was especially strong among more-educated (more than a high school degree), older (more than 20 years of potential experience), and non-white workers.

We used a similar approach to generate housing price outcome indices for each residence area in the sample. With respect to housing, there are two price measures in the Census data: homeowners estimate the value of their homes – we refer to this as the value measure; and renters report the rent they pay on their homes – we refer to this as the rent measure. We used each of these measures to generate indices for fixed housing characteristics. We divided the data into 128 cells on the basis of housing type (detached single units, and 3 gradations of units in the building), size (4 categories based on number of bedrooms X 2 categories based on the number of other rooms), and age (4 categories). We then computed indices of the change in value or rent based on equation (3), with μ_i the share of total value in the sample corresponding to cell *i*.

Table 1B describes housing price indices we generated. Based on the homeowners' valuations, the average housing price change in our 1,951 residence areas was a 15.7 percent increase, holding housing characteristics fixed. The Rental index, on the other hand, indicates a 21.4 percent decline in value among rented properties. It is unclear why these measures produced such different results, but the value index seems more reasonable, both in its overall average, and in the fact that it shows relative increases for larger, newer, and detached units (the rental index shows the opposite). Given this, and the fact that it embodies more data, we emphasize the results based on this index in our analysis. Both indices show substantial variation across residence areas.

To measure the relationship between these outcomes and the changing job opportunities facing workers who live in the residence areas, we created two different measures of job accessibility changes. For the first measure, we used job counts available by county of workplace available from the Bureau of Economic Analysis's REIS database. These publicly available, REIS data are derived from the ES202 program of the Bureau of Labor Statistics, which uses Unemployment Insurance records to accurately document employment totals. In order to map the REIS job counts onto place of residence space, we used county-of-work data from the Census of Population to measure the share of workers within each residence area *r* who work in each work county *c*. We then computed the county-based job accessibility measure for residence area *r* as:

$$\Delta J_r^C = \sum_c share_{rc} \cdot \Delta J_c \tag{4}$$

where $share_{rc}$ is the commuting share from residence area *r* to workplace county *c* and ΔJ_c is the workplace county job count change obtained from the REIS data. To calculate $share_{rc}$, we averaged the commuting shares from the 1990 and 2000 Census. The average of this job change measure across all of the residence areas in our sample was .111, indicating that the average residence area experienced an increase in the number of locally available jobs. The standard deviation was .105, indicating a fair amount of variation between residence areas.

The second measure of the change in job availability that we use is constructed similarly to the first, except it is derived entirely from Census of Population place-of-work (POW) data. Workers in the Census data report the locations of their workplaces, and the information is translated into tract-level detail in the microdata. To work with these POW-tract data, we first aggregated them into geographic units that are consistently defined over time, which we call "tract groups." We then calculated the job growth within each tract group and the commuting fractions to each tract group from each residence area and compute the tract-based job measure for each residence area as:

$$\Delta J_r^T = \sum_t share_{rt} \cdot \Delta J_t \tag{5}$$

where $share_{rt}$ is the commuting share from residence area *r* to workplace tract group t and ΔJ_t is the workplace tract group job count change obtained from the Census's POW tract data. Note that the tract-based job growth measure has both advantages and disadvantages in comparison to the county-based data used in the first jobs measure. It embodies more detail on job locations, because tract groups are generally smaller than counties. But it also contains more measurement error, because the place-of-work geographical detail provided by the household survey is more incomplete and error-prone (especially at this heightened level of detail) than the establishment survey underlying the REIS data. The average of this measure across all residence areas in our sample was -.028. This negative value may have resulted from the different methods used to impute for missing data in the 1990 and 2000 Censuses. Nonetheless, if any resulting error is not systematic over space, the measure may still be valuable for comparing the effects of relative job shifts. The standard error of the measure was .153.

These job count change figures by residence area reflect labor demand changes in the area, but they may also be affected by supply shocks or population movements. For example, if changes in the value of residential amenities caused population movements among residence areas, then the job growth near areas of growing population will have increased due to shifts in labor supply. We attempted to solve this difficulty by focusing on the national decline in aircraft manufacturing outlined above. To do so, we instrumented for ΔJ_r with measures of the share of aircraft manufacturing employment in each residence area, AIR_r. These shares are calculated as an average of the 1990 and 2000 aircraft manufacturing shares of employment among area residents, using the Census of Population data.[4] In our sample, this fraction was calculated to have an average value of .0122 across residence areas, with 6.92 percent of residence areas having a value greater than .05.

[4] For the tract-based employment change measure, we calculated an alternative measure of AIR. In this measure, we calculated the share of aircraft employment in each tract group and then computed for each residence area the commute-weighted average of these tract group aircraft fractions. This alternative measure had an average of .0118

Estimation Methodology

To estimate the effects of changes in local labor demand, the methodology we implement closely relates to that used by Bound and Holzer (2000) and, especially, Dworak-Fisher (2004). We estimate a reduced form model measuring the elasticities of various labor market outcomes with respect to local job changes. Our dependent variables are the fixed composition outcome indices O_{ISr}^{fixed} defined above measuring the change in various outcomes of interest for each broad demographic group *I* in residence area *r*. We estimate the equation:

$$O_{ISr}^{fixed} = \alpha_I + \beta_I \Delta J_{Sr} + \gamma_S + \varepsilon_{ISr}\,, \qquad (6)$$

where ΔJ_{Sr} represents the growth of jobs in residence area *r* over the decade, as measured alternately by our two measures, ΔJ_{Sr}^{C} and ΔJ_{Sr}^{T}, and γ_S is a study area fixed effect. Our estimates of β_I reflect the elasticity of labor market outcomes with respect to job changes in the area of residence. Since we estimate separate elasticities for each broad demographic group, we measure differences in their behavior. The study area fixed effects allow us to control the effects of shifts in labor supply and demand between different parts of the country: the implicit comparison we make in these regressions are between residence areas that are very near to aircraft employment concentrations and residence areas within the same general area as the aircraft concentration but not close enough to be affected by the aircraft employment shock.

As described above, we instrument for ΔJ_{Sr} using the share of area *r*'s employment that is in the aircraft manufacturing industry, AIR_{Sr}.

$$\Delta J_{Sr} = a + b \cdot AIR_{Sr} + \gamma_S + \eta_r\,. \qquad (7)$$

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across residence areas.

Our interpretation of the first stage coefficient b is that it measures the extent to which job shocks spill over into other sectors via multiplier effects, attenuated by the extent to which job counts recover from the shock by the end of the decade.

A key econometric issue in estimating these models is how to properly account for spatial correlations among our measures and in the error term (ε_{iSr}) of equation (6). The construction of ΔJ_{Sr} accounts for job growth in nearby areas, but some residual effects of geographic spillovers in labor demand may still be present in the error term. It also seems likely that exogenous innovations wages, employment, or population in one residence area may be correlated with similar innovations in nearby residence areas. We use the spatial error model, which assumes spatial correlations in the error term (ε_{iSr}), and the spatial lag model, which assumes spatial correlations in the effects of job growth (ΔJ_{Sr}), to explore the effects of these correlations on our results. In doing so, we use the average latitude and longitude of block in our residence areas as measures of the location of each residence area. We compute the distances between residence areas based on these coordinates, and we specify correlations between residence areas as multiples of the inverses of these distances.

Results

Table 2 displays the results of OLS, spatial error and spatial lag models of changes in labor market outcomes based on equation (6). In it, residence areas are defined as having at least 10,000 residents in the year 2000, and job changes are measures using the county-based REIS data. In the first three columns, the job shift measure is entered directly – the OLS results report a straightforward application of equation (6). In the 3 columns to the right, the job shift variable is predicted from a first stage regression as in equation (7); this mimics the coefficient estimate (but not the standard error) from the IV regressions to follow, giving us an opportunity to explore how modeling spatial structure might affect IV estimates.

The OLS estimates of the effect of local job changes on labor market outcomes indicate moderate, but significant long-term effects on wage and employment rates and a large effect on population counts. A 10 percent rise in the number of accessible jobs is associated with a 2 percent increase in wages and a 0.6 percent increase in weeks worked among residents of a particular area, and a 12 percent increase in the population of the area. Looking down the first 3 columns, we see that this assessment is not changed much by incorporating spatial correlations in the error term of the model or by incorporating a spatial lag in the explanatory variable. In the wage equations, the spatial lag parameter estimates are both negative and statistically insignificant, a surprising result that reduces confidence in the associated results. In the weeks worked and population equations, the spatial error parameter is very close to 1, indicating a high degree of spatial correlation. In the spatial lag model, the lag parameter for weeks worked is statistically insignificant, but the parameter in the population equation is positive and significant. Further, the estimated effect on population changes now indicates a 14 percent increase in population in response to a 10 percent increase in jobs.

The final three columns of Table 2 show the simulated measurements of instrumental variables estimation under the OLS, spatial error, and spatial lag models. In the first row, we see that instrumenting for job shifts with the aircraft fraction of employment causes dramatic increases in the measured effects on wages, weeks worked, and population changes: a 10 percent shift in local labor demand due to the declines in aircraft manufacturing is associated with a 22 percent change in wages, a 3 percent change in weeks worked, and a 35 percent change in population. These dramatic effects, especially on wages and population, suggest that the decline in aircraft employment in localized areas resulted in a transformation of the local economy, as wages deteriorated and populations fled. Looking down the columns, this measurement does not seem to be affected much by the incorporation of correlations in the errors or lagged effects in the explanatory variable. There is one exception: the spatial lag model for population indicates a large and significant lag parameter and a much smaller (and insignificant) measure of the effect of job shifts on population.

These instrumental variables estimates were achieved using the 1990 fraction of residents employed in aircraft manufacturing in each residence area as the instrument for the job accessibility growth measure, as described above. The first stage, described by equation (7), resulted in a coefficient estimate of -.342 on the aircraft fraction of employment. Given that aircraft manufacturing employment declined by 45 percent in the average residence area in our sample, this suggests that job growth made some recovery from the initial shock caused by the decline of aircraft jobs, but significant effects on the location of jobs still remained by the end of the decade. The partial R-squared for this first stage regression was .0043, indicating that aircraft's decline explains only a small fraction of the job shifts seen in the sample during the 1990s.

Table 3 shows the results of OLS and IV estimations of the model, without incorporating spatial correlations, for the full sample and for various demographic sub-groups. Measured by OLS, the moderate effects of job shifts on wages and weeks worked are seen to fall somewhat unevenly on different demographic groups. Most notably, less-educated workers appear to experience greater employment effects in terms of weeks worked than do more-educated workers, and the wages of older workers seem to be more affected by local job shifts than do the wages of younger workers.

In the IV estimates in the right three columns of Table 3, a different picture emerges. As noted above, the full sample estimated effects of the shift in demand from aircraft manufacturing's decline are quite large. But now we also see, with the benefit of standard errors estimated properly for the IV model, that our estimated effects are statistically significant for wage and population adjustments, but statistically insignificant for adjustments in weeks worked. Looking down the column, we continue to see that the estimated effects of aircraft-related declines in local jobs are substantively, but not statistically, significant.

The comparison between the IV estimates of wage and population changes of different demographic subgroups suggest important differences in the experiences of these groups. The measured effect of aircraft-related job shifts on wages is substantially higher for more-educated workers than for less-educated workers. This likely reflects the fact that aircraft employment is disproportionately comprised of more-educated workers – the labor demand shock we are exploiting was biased towards these workers. With this in mind, it is perhaps unsurprising that the population response to the job shifts was greater among more-educated than among less-educated workers. The measured population response among more-educated workers is extremely large, implying that a 10 percentage point decline in locally available jobs results in a 55 percent decline in the more-educated population. These measures reinforce the notion of a transformative effect of the aircraft manufacturing decline: not only did population decline in areas hardest hit by the aircraft manufacturing decline, but it declined most for more-educated workers.

The wage and population effects were also pronounced for younger workers in comparison to older workers. This may be reflective of younger workers' having less job security on the one hand and greater geographic mobility on the other hand. Alternatively, it may be that the decline in aircraft jobs themselves was biased towards younger workers. Finally, the racial differences in population changes show the starkest contrast in Table 3. It appears that the wage and employment effects of the aircraft-related job shifts accrued somewhat more heavily to non-white workers than to white workers, but the population responses of these two groups were diametrically opposed. The IV results for population change indicate that the population of non-white workers grew markedly in areas where jobs declined due to aircraft manufacturing declines. Conversely, white populations declined markedly in these areas. According to the results, a 10 percent decline in available jobs was met by 64 percent increase in the non-white population and a 55 percent increase in the white population. These results suggest that the transformation in the local economy that was wrought by aircraft manufacturing declines included a dramatic change in the racial composition of nearby communities.

In Table 4, we show the results of an analysis similar to the one carried out in generating Table 3, except we have used our alternative job change measure, based on the tract-based job counts we estimated from the Census Place-of-Work data. These results also indicate significant associations between local job growth and labor market outcomes for the full sample, but they indicate associations of a smaller magnitude. The elasticities estimated by OLS are roughly a third of the size of the estimates obtained from the county-based jobs measure, and the elasticities estimated by IV are about a half to two-thirds as large. This diminished sized suggests that the increased measurement error inherent in the alternative jobs measure has resulted in attenuated estimates. Nonetheless, the estimates of the effects of the job shifts on different demographic groups generally mirror those using the county-based jobs measure. In particular, the IV estimates indicate larger wage and population effects on more-educated and younger workers, and the divergent population effects by race are reproduced.

In Tables 5A and 5B, we explore the extent to which these results are sensitive to the way in which we created the residence areas in generating the data set underlying our analysis. Table 5A shows the OLS and IV estimates for the full sample and the various demographic subgroups when residence areas were defined to have a minimum of 5,000 residents in year 2000, resulting in 4,196 residence areas being included in the study areas. In Table 5B, the residence areas were defined to have a minimum of 15,000 residents in year 2000, resulting in 1,242 residence areas being included. The estimates using the smaller residence areas in Table 5A are somewhat smaller in magnitude than the results in Table 3, especially in the IV analysis. These smaller geographic delineations may have caused increased imprecision in the jobs measure, which could explain the decreased parameter estimates. Nonetheless, the results for these smaller residence areas are qualitatively similar to those in our base case; in particular, the differences between demographic groups are consistent with the base case. The estimates using larger residence areas shown in Table 5B are very similar to the base case in every case. At least qualitatively, it does not appear that our results are sensitive to the level of geographic aggregation at which we generated the data underlying our data.

In Table 6, we report the estimated effects of local job shifts on the housing prices of a residence area, again providing OLS, spatial error, and spatial lag estimates for the full sample. When we do not instrument for the job shifts, we measure a significant and positive effect for our value index, but a significant and negative effect for our rent index. It is surprising that these measured effects are so different, but we have more confidence in the value index because it embodies more observations, especially on detached and larger units. In any case, these measures do not change very much when we incorporate spatial correlations in the error term. In the right two columns of Table 6, we show the estimates using as our explanatory variable the predicted job shifts from a first stage regression of job change on aircraft employment, again simulating the IV estimation to follow. The effects are measured to be large and positive for both the value index and the rent index: a 10 percent relative decline in accessible jobs predicts a 67 percent decline in housing value and a 139 percent decline in rental value relative to other residence areas. These effects are consistent with the story being told in by our measures of labor market effects: the decline in jobs associated with aircraft manufacturing's decline caused a substantial transformation in the nearby communities.

Table 7 explores the contours of these housing price effects on housing units having different broad characteristics. According to the IV estimates, the dramatic effects on housing prices associated with the aircraft manufacturing decline were especially marked among larger housing (homes with more than 2 bedrooms), older housing (homes more than 20 years old), and detached housing. With respect to larger and detached housing, these results again seem to reflect the fact that the effects of the decline in aircraft manufacturing fell especially hard on more-educated workers. The relatively smaller effect on newer housing may reflect a supply response – fewer new houses may have been built in areas that were affected by the declines.

Conclusions

We began this study asking whether any effects on labor market and housing outcomes persist over a decade when a shock to local labor demand is experienced. One possible long run outcome of such a shock is for new labor demand to replace the loss, restoring the original equilibrium. This is a jobs-following-population type of story that is sometimes advocated. Alternatively, within relatively small geographic areas like the study areas we have studied here, it is possible that "space does not matter" – that measures of local job accessibility are inconsequential compared to the residential amenities that determine the distribution of residents within large metropolitan areas. Such a story would also have predicted that changes in the relative accessibility of jobs within study areas would not have effects on labor market or housing price outcomes. Discounting these potential stories, the question we were interested in amounted to whether population movements would be large enough over the course of a decade to restore the original wage and employment rates, at the expense of housing price declines.

The results we have found in studying the effects of declines in locally accessible jobs originating from aircraft manufacturing declines suggest a different story: a large shock to labor demand can have transformative effects on a local economy that go well beyond the impact on accessible jobs. In the case of the decline of aircraft manufacturing we have measured elasticities to the demand shift that portray a transformative effect. Job decline related to declines in aircraft manufacturing employment were associated with relative wage declines more than twice as great, relative population declines more than three times as great, and relative housing price decline more than six times as great. This type of transformation underlines the importance of agglomeration effects in the determination of the economic landscape.

References

Bartik, Timothy J. (1991) *Who Benefits from State and Local Development Policies?* Kalamazoo, MI:W.E. UpJohn Institute.

______________. (1993) “Who Benefits from Local Job Growth: Migrants or the Original Residents?” *Regional Studies,* vol. 27.4, pp. 297-311.

Black, Dan; Terra McKinnish; and Seth Sanders (2003) “The Economic Impact of the Coal Boom and Bust.” *Economic Inquiry*, forthcoming.

Blanchard, Olivier Jean and Lawrence F. Katz. (1992) “Regional Evolutions.” *Brookings Papers on Economic Activity*, vol. 0, no. 1,, pp. 1-73.

Bound, John and Harry Holzer. (2000) “Demand Shifts, Population Adjustments, and Labor Market Outcomes: 1980-1990.” *Journal of Labor Economics*, 18(1), pp. 20-54.

Carrington, William J. (1996) “The Alaskan Labor Market in the Pipeline Era.” *Journal of Political Economy*, vol.104, no. 1. pp. 186-218.

Dworak-Fisher, Keenan (2004) “Intra-Metropolitan Shifts in Labor Demand and the Adjustment of Local Markets.” *Journal of Urban Economics*, vol. 55, no. 3, May 2004.

Gallin, Joshua Hojvat. “Net Migration and State Labor Market Dynamics.”*Journal of Labor Economics*, volume 22 (2004), pp 1–21.

Glaeser, Edward L. and Joseph Gyourko. “Urban Decline and Durable Housing.” *Journal of Political Economy*, volume 113 (2005), pp. 345–000.

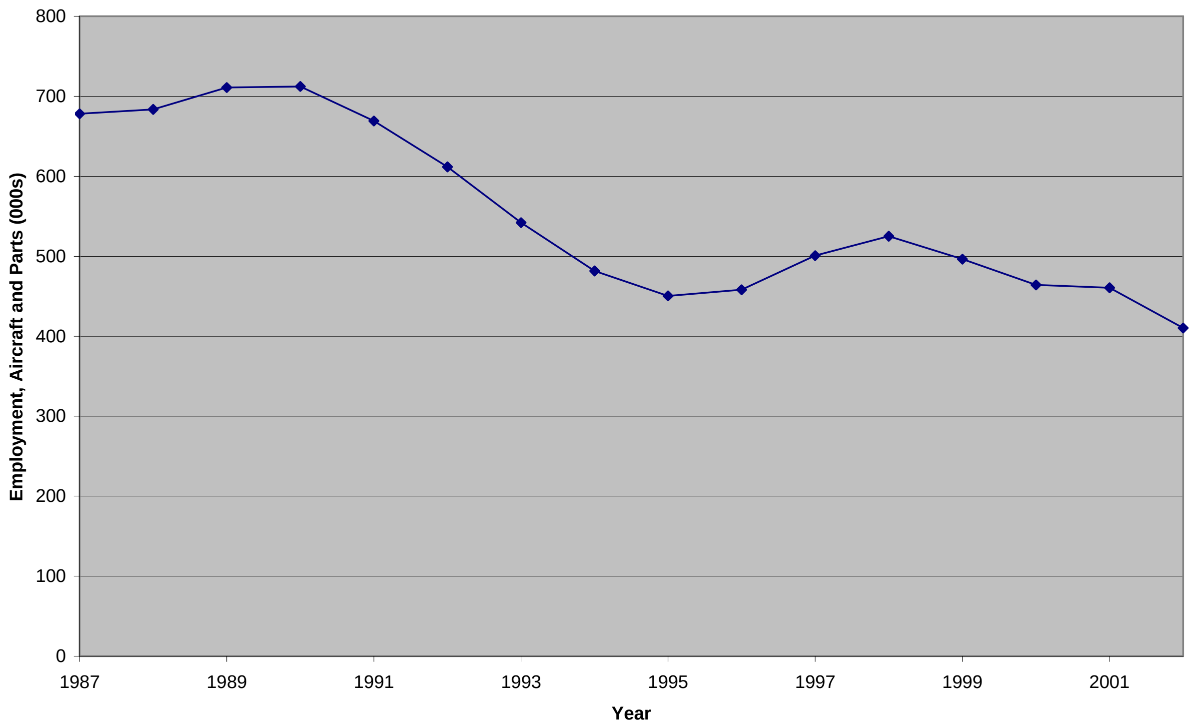
Krizan, C. J. (1998) “Localized Effects of California’s Military Base Realignments: Evidence from Multi-Sector Longitudinal Microdata.” Center for Economic Studies Discussion paper.

Kronemer, Alexander and J. Edwin Henneberger (1993) “Productivity in Aircraft Manufacturing.” *Monthly Labor Review*, June 1993. pp. 24-33.

Ong, Paul M. and Janette R. Lawrence. (1995) “Race and Employment Dislocation in California’s Aerospace Industry.” *The Review of Black Political Economy*, Winter, pp. 91-101.

Topel, Robert H. (1986) "Local Labor Markets." *Journal of Political Economy*, vol. 94, no. 3, pp. S111-S143.

Figure 1: Annual U.S. Aircraft Manufacturing Employment, 1987-2002



Source: U.S. Bureau of Labor Statistics, *Current Employment Statistics*, 1987-2002.

Table 1A: Summary Statistics for Labor Market Outcome Indices among Residence Areas

Variable	Mean	Standard Deviation
<u>All residents</u>		
Wage Index	0.298	0.088
Weeks Worked Index	0.001	0.052
Population Index	0.128	0.274
<u>Less-Educated residents</u>		
Wage Index	0.267	0.087
Weeks Worked Index	0.000	0.060
Population Index	0.068	0.262
<u>More-Educated residents</u>		
Wage Index	0.338	0.161
Weeks Worked Index	0.006	0.078
Population Index	0.191	0.371
<u>Younger residents</u>		
Wage Index	0.302	0.100
Weeks Worked Index	0.000	0.060
Population Index	-0.057	0.299
<u>Older residents</u>		
Wage Index	0.270	0.093
Weeks Worked Index	0.007	0.055
Population Index	0.299	0.287
<u>Non-White residents</u>		
Wage Index	0.321	0.177
Weeks Worked Index	0.011	0.132
Population Index	0.377	0.375
<u>White residents</u>		
Wage Index	0.294	0.100
Weeks Worked Index	-0.001	0.063
Population Index	0.079	0.308

Table 1B: Summary Statistics for Housing Price Outcome Indices among Residence Areas

Variable	Mean	Standard Deviation
All Units		
Value Index	0.157	0.184
Rental Index	-0.214	0.321
Smaller Units		
Value Index	0.101	0.301
Rental Index	0.268	0.249
Larger Units		
Value Index	0.168	0.205
Rental Index	-0.316	0.381
Newer Units		
Value Index	0.193	0.460
Rental Index	-0.416	0.383
Older Units		
Value Index	0.155	0.190
Rental Index	-0.178	0.341
Detached Units		
Value Index	0.171	0.220
Rental Index	-0.488	0.453
Attached Units		
Value Index	0.129	0.286
Rental Index	0.286	0.230

Table 2: Estimates of Effects of Job Growth on Labor Market Outcomes
Comparison of OLS, Spatial Error, and Spatial Lag Models
(Using County-Based Jobs Measure)
(standard errors in parentheses)

	Direct Estimates			**2-Stage Estimates**		
	Wage	**Weeks Worked**	**Populatio n**	**Wage**	**Weeks Worked**	**Populatio n**
OLS	0.200	0.062	1.192	2.222	0.289	3.494
	(0.028)	(0.012)	(0.089)	(0.432)	(0.268)	(1.439)
Spatial Error	0.185	0.062	1.193	2.177	0.295	3.527
	(0.031)	(0.017)	(0.089)	(0.409)	(0.270)	(1.443)
Lambda	-13.730	0.987	0.999	-77.300	0.992	0.998
	(13.418)	(0.128)	(0.008)	(20.611)	(0.068)	(0.012)
Spatial Lag	0.183	0.056	1.400	2.403	0.281	0.829
	(0.031)	(0.019)	(0.086)	(0.431)	(0.267)	(1.423)
Rho	-20.027	67.818	1038.274	-64.695	204.544	815.840
	(14.883)	(103.687)	(75.068)	(13.530)	(92.182)	(80.140)

Table 3: OLS and IV Estimates of Effects of Job Growth on Labor Market Outcomes Among Full Sample and Broad Demographic Sub-Groups (Using County-Based Jobs Measure)

(standard errors in parentheses)

	OLS Estimates			IV Estimates		
	Wage	**Weeks Worked**	**Population**	**Wage**	**Weeks Worked**	**Population**
All Residents	0.200	0.062	1.192	2.222	0.289	3.494
	(0.028)	(0.017)	(0.089)	(0.831)	(0.279)	(1.599)
Less-Educated Residents	0.191	0.115	1.068	1.657	0.364	1.714
	(0.027)	(0.020)	(0.084)	(0.668)	(0.322)	(1.323)
More-Educated Residents	0.253	-0.034	1.528	3.136	0.243	5.549
	(0.055)	(0.028)	(0.121)	(1.324)	(0.438)	(2.352)
Younger Residents	0.096	0.070	1.039	3.416	0.395	6.932
	(0.032)	(0.020)	(0.099)	(1.272)	(0.332)	(2.581)
Older Residents	0.204	0.047	1.212	2.123	0.246	3.447
	(0.030)	(0.019)	(0.094)	(0.818)	(0.296)	(1.651)
Non-White Residents	0.139	0.055	1.026	2.726	1.322	-6.436
	(0.061)	(0.046)	(0.127)	(1.314)	(0.846)	(3.283)
White Residents	0.188	0.052	1.060	2.062	0.207	5.463
	(0.033)	(0.021)	(0.103)	(0.832)	(0.338)	(2.229)

Table 4: OLS and IV Estimates of Effects of Job Growth on Labor Market Outcomes Among Full Sample and Broad Demographic Sub-Groups (Using POW Tract-Based Jobs Measure)

(standard errors in parentheses)

	OLS Estimates			IV Estimates		
	Wage	**Weeks Worked**	**Population**	**Wage**	**Weeks Worked**	**Population**
All Residents	0.068	0.025	0.402	1.486	0.140	1.589
	(0.013)	(0.008)	(0.042)	(0.821)	(0.198)	(1.180)
Less-Educated Residents	0.057	0.038	0.346	1.094	0.183	0.478
	(0.013)	(0.009)	(0.039)	(0.633)	(0.232)	(0.937)
More-Educated Residents	0.090	0.003	0.508	2.108	0.132	2.792
	(0.025)	(0.013)	(0.057)	(1.240)	(0.308)	(1.821)
Younger Residents	0.040	0.024	0.321	2.365	0.221	4.093
	(0.015)	(0.009)	(0.046)	(1.300)	(0.244)	(2.305)
Older Residents	0.071	0.018	0.424	1.419	0.116	1.518
	(0.014)	(0.009)	(0.044)	(0.794)	(0.209)	(1.193)
Non-White Residents	0.028	0.025	0.196	1.889	0.842	-5.216
	(0.028)	(0.021)	(0.059)	(1.202)	(0.669)	(3.232)
White Residents	0.072	0.023	0.396	1.378	0.083	2.963
	(0.015)	(0.010)	(0.048)	(0.788)	(0.236)	(1.788)

Table 5A: OLS and IV Estimates of Effects of Job Growth on Labor Market Outcomes Among Full Sample and Broad Demographic Sub-Groups, Residence Areas: Minimum of 5,000 Residents

(standard errors in parentheses)

	OLS Estimates			IV Estimates		
	Wage	**Weeks Worked**	**Populatio n**	**Wage**	**Weeks Worked**	**Populatio n**
All Residents	0.185	0.073	1.077	1.589	0.132	1.633
	(0.020)	(0.122)	(0.058)	(0.341)	(0.142)	(0.672)
Less-Educated Residents	0.178	0.110	1.006	1.278	0.129	0.733
	(0.020)	(0.014)	(0.055)	(0.305)	(0.165)	(0.639)
More-Educated Residents	0.233	0.019	1.310	1.934	0.150	2.169
	(0.040)	(0.024)	(0.082)	(0.558)	(0.281)	(0.958)
Younger Residents	0.109	0.069	0.936	2.036	0.100	3.360
	(0.024)	(0.015)	(0.065)	(0.438)	(0.172)	(0.867)
Older Residents	0.185	0.061	1.092	1.598	0.126	1.578
	(0.022)	(0.013)	(0.061)	(0.354)	(0.152)	(0.703)
Non-White Residents	0.171	0.011	0.784	1.449	-0.444	-3.066
	(0.028)	(0.038)	(0.085)	(0.637)	(0.454)	(1.202)
White Residents	0.179	0.078	0.889	1.514	0.161	2.835
	(0.024)	(0.015)	(0.066)	(0.367)	(0.178)	(0.841)

Table 5B: OLS and IV Estimates of Effects of Job Growth on Labor Market Outcomes Among Full Sample and Broad Demographic Sub-Groups, Residence Areas: Minimum of 15,000 Residents
(standard errors in parentheses)

	OLS Estimates			IV Estimates		
	Wage	**Weeks Worked**	**Population**	**Wage**	**Weeks Worked**	**Population**
All Residents	0.230	0.062	1.247	2.450	0.311	3.208
	(0.031)	(0.017)	(0.100)	(1.077)	(0.283)	(1.749)
Less-Educated Residents	0.204	0.102	1.073	2.177	0.312	1.481
	(0.030)	(0.020)	(0.094)	(0.973)	(0.322)	(1.451)
More-Educated Residents	0.277	-0.003	1.657	2.976	0.308	5.184
	(0.059)	(0.030)	(0.136)	(1.483)	(0.475)	(2.581)
Younger Residents	0.125	0.071	1.108	3.603	0.295	6.386
	(0.037)	(0.022)	(0.111)	(1.611)	(0.356)	(2.847)
Older Residents	0.235	0.046	1.271	2.455	0.199	3.243
	(0.033)	(0.018)	(0.106)	(1.090)	(0.281)	(1.831)
Non-White Residents	0.221	0.122	1.214	2.587	2.086	-7.023
	(0.060)	(0.048)	(0.149)	(1.375)	(1.127)	(4.237)
White Residents	0.232	0.050	1.147	2.418	0.075	5.355
	(0.036)	(0.019)	(0.117)	(1.096)	(0.290)	(2.556)

Table 6: Estimates of Effects of Job Growth on Housing Price Outcomes
Comparison of OLS, Spatial Error, and Spatial Lag Models
(Using County-Based Jobs Measure)
(standard errors in parentheses)

	Direct Estimates		**2-Stage Estimates**	
	Value	**Rent**	**Value**	**Rent**
OLS	0.457	-0.257	6.669	13.923
	(0.054)	(0.093)	(0.836)	(1.407)
Spatial Error	0.457	-0.258	6.687	14.448
	(0.054)	(0.093)	(0.833)	(1.409)
Lambda	0.997	0.995	0.997	-19.152
	(0.014)	(0.010)	(0.007)	(14.239)
Spatial Lag	0.501	-0.309	5.402	9.634
	(0.052)	(0.088)	(0.827)	(1.391)
Rho	573.121	968.449	482.393	847.230
	(50.352)	(65.304)	(51.533)	(66.661)

Table 7: OLS and IV Estimates of Effects of Job Growth on Housing Price Outcomes Among Full Sample and Broad Housing Sub-Groups (Using County-Based Jobs Measure)

(standard errors in parentheses)

	OLS Estimates		IV Estimates	
	Value	**Rent**	**Value**	**Rent**
All Housing	0.457	-0.257	6.669	13.923
	(0.054)	(0.093)	(2.340)	(5.195)
Smaller Housing	0.417	0.177	4.370	4.122
	(0.106)	(0.086)	(2.223)	(1.986)
Larger Housing	0.490	-0.377	7.280	15.945
	(0.059)	(0.107)	(2.560)	(5.982)
Newer Housing	0.041	-0.029	5.814	3.679
	(0.159)	(0.134)	(3.196)	(2.457)
Older Housing	0.465	-0.297	6.733	14.937
	(0.057)	(0.099)	(2.377)	(5.577)
Detached Housing	0.518	-0.502	8.003	17.126
	(0.063)	(0.125)	(2.793)	(6.464)
Attached Housing	0.398	0.186	2.524	9.361
	(0.100)	(0.079)	(1.794)	(3.609)